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ASSEMBLY OF THE U.G.G.I. AT OSLO, AUGUST 1948

BY C. S. DURST, B.A.

The International Union of Geodesy and Geophysics (U.G.G.I. as it is usually called) is a confederation of several international Associations and Commissions whose object is, by international co-operation, to further scientific research and investigation in their various fields of geodetic and geophysical study. At the present time there are seven of these constituent international Associations concerned with the following subjects: (1) geodesy, (2) seismology, (3) meteorology, (4) terrestrial magnetism and electricity, (5) oceanography, (6) vulcanology and (7) hydrology. These organizations function more or less autonomously within the Union.

The U.G.G.I. is one of nine international scientific unions which adhere to the International Council of Scientific Unions (I.C.S.U.), and through this Council the U.G.G.I. adheres to the United Nations Economic, Social and Cultural Organization (U.N.E.S.C.O.).

The U.G.G.I. and its component Associations and Commissions normally meet in General Assembly every three years. Assemblies have been held in Rome (1922), Madrid (1924), Prague (1927), Stockholm (1930), Lisbon (1933), Edinburgh (1936) and Washington (1939). The outbreak of war seriously interfered with the last assembly, and that held in Oslo from August 19 to 28, 1948 has had to link up threads over a gap of nine years.

The usual procedure at a General Assembly is for all delegates to meet at an opening session, after which the several Associations adjourn to separate meeting places for their own business and scientific discussions. At the end of the Assembly all the delegates meet again to agree on important major resolutions and decisions, and also to conduct the business of the Union such as the election of officers.

Such is in broad outline the function of U.G.G.I. In the third week of last August there converged on Oslo 400 delegates from 37 nations by railway, steamship and plane. The British delegation was the most numerous with 62 members, the U.S.A. had a membership of 51, and there were delegates from as far afield as the Philippines, Ecuador and Iceland.

The present writer arrived in a plane load of scientists on the 18th.

Our first sight of Norway was of sunlit islands fringing the southern coast around Christiansund but by the time the plane had turned into Oslo Fjord the frontal clouds had closed down and we landed in teeming rain. That was typical of the Norwegian weather we experienced ; rain which did its best to spoil expeditions, and periods of bright sunshine with amazing visibilities over the mountain tops. But, whatever the weather, there was no lack of warmth and welcome in the entertainment which our Norwegian hosts provided for us and which they crowned with a marvellously planned meteorological excursion at the conclusion of the Congress, an excursion which carried us through the heart of the Jotunheim and to the summit of Fanaråken and finally bore us on board the Norwegian ocean weather ship *Polarfront I* down the Sogn Fjord to be welcomed and speeded home from Bergen.

The Oslo Assembly was held in the University buildings, and there in the gaily painted Aula the opening ceremony was performed on August 19 in the presence of the King of Norway. There we assembled to hear speeches of welcome interspersed with orchestral music and an eloquent reply by Dr. Norlund, Acting President of the Union.

That ceremony ended, the Conference broke up into its several Associations, often with congested programmes which could hardly be compressed into three-hourly sessions, morning and afternoon, throughout the seven working days.

The Meteorological Association was presided over by Prof. S. Chapman with Prof. J. Bjerknes as Secretary. However, in response to a request by these officers, a change was made when Prof. J. Bjerknes was elected president and Prof. J. van Mieghem (Belgium) was chosen Secretary.

In his presidential address Prof. Chapman made a strong case for an International Meteorological Research Organization to link together the various meteorological research bodies throughout the world and to serve as a clearing house for ideas. He took as his pattern the British Meteorological Research Committee, and urged that there were many problems which could be far more satisfactorily handed over to an international body than left to the efforts of the national organizations. Among such problems he cited those concerned with the computation of forecasts by electronic methods, the world-wide examination of the effects of ozone and the further discussion of lunar and solar tides in the atmosphere.

In a brief space it is not possible to describe the many notable lectures which were given to the Meteorological Association but, looking back, the most outstanding impression was that created by the discussions on rain-making by artificial means. Early in the Conference a pronouncement was given by Dr. Reichelderfer (U.S.A.) that, in all the experiments made in the United States, there was no recorded case in which seeding a cloud with dry ice, had produced rain when rain from natural causes had not fallen within 30 miles. He confirmed that cloud had been dissipated locally by the use of dry ice, but it was doubted whether there was in fact any practical possibility of rain-making on an extensive scale. The same conclusion was reached in a masterly exposition by Prof. Bergeron (Sweden) who enumerated the cloud types from which precipitation might be derived by suitable seeding. He emphasised, however, that excessive seeding might actually prevent precipitation. Then he went on to point out that in some topographical situations, where the artificial pro-

duction of rain might be most effective on physical grounds, there was already a superabundance of natural precipitation and suggested the possibility that overseeding in those regions might be used to prevent the clouds shedding their water on the windward side of hills with consequent benefit to the drier localities to leeward. Dr. Pawsey of Australia was more optimistic on the economic aspect of rain-making and cited the case* in which precipitation had been actually produced by skilful seeding, precipitation which had been sufficient in amount to fill the dry water-storage tank of an Australian farmhouse.

A contribution which was generally accepted by the delegates as being of major importance was that given by Dr. Eady (Gt. Britain). He gave a resumé of his theory of selective unstable waves in an atmosphere limited by the boundaries of the tropopause and the earth's surface ; into this atmosphere there are introduced baroclinic cloud layers involving further boundary conditions. Computations based on his theory, he claimed, had shown a remarkable similarity to the facts of short-lived cyclonic formation and progression on the one hand and of long-period waves related to more persistent weather types on the other.

A most engrossing film was shown by Prof. Byers (U.S.A.), in which was exhibited, in slow motion, the records of the radar reflection from rain (on a P.P.I. screen) during thunderstorms over Florida. In them could be seen the cellular structure of the storms and the progressive developments of the rain areas. In a talk on the subject of the "Thunderstorm Project" Prof. Byers emphasised that for the development of a cumulonimbus cloud it was necessary that down currents be engendered and that cooling of air by rain played a very important part in the process. He further pointed out that the coldness of gusts connected with the arrival of a thunderstorm was due to air entrained into the down current during its descent.

Prof. Palmén (Finland) showed some interesting examples of jet streams†. He then went on to describe how in some circumstances a narrow tongue of cold tropospheric air might protrude southwards, and how the jet stream might cut across this tongue leaving to the south a region of low tropopause and high stratospheric temperature. In this region cyclonic rotation was present and on the eastern side of the region precipitation occurred.

A very clear statement of the fundamental problems in the study of radiation was given by Dr. Nicolet (France).

In conjunction with the Associations of Seismology and Oceanography one session was devoted to the discussion of microseisms. It was interesting to hear how successful the Americans had been in locating the positions and movements of tropical revolving storms by means of the microseisms recorded at two tripartite seismographic stations. Each tripartite station consists of three seismographs at distances of 200 or 300 m. from each other. From these the direction of the source can be discovered, and thus from two such tripartite stations the centre of the disturbance can be accurately plotted. The origin of the microseisms gave rise to several papers. Standing waves are

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*KRAUS, E. B. and SQUIRES, P.; Experiments on the stimulation of clouds to produce rain. *Nature, London*, **159**, 1947, p. 489.

†PALMÉN, E.; On the distribution of temperature and wind in the upper westerlies. *J. Met., Lancaster, Pa.*, **5**, 1948, p. 20.

formed by the crossing of swells formed in different quadrants of tropical storms and it may be demonstrated that standing-wave systems of this nature can produce pressure variations of half the period of the standing waves, even at the bottom of an ocean.

The density of the high atmosphere was ingeniously discussed by Dr. F. L. Whipple (U.S.A.). Simultaneous records are made of the passage of meteorites by photography, the records of the trail being interrupted at short intervals by a rotating shutter. The mass of the meteorite can be determined from its luminosity and velocity, the height being deduced from trigonometrical methods. The density of the atmosphere can then be deduced from the deceleration of the body. The velocity of the meteorites was found to vary from 50 or 60 m./sec. to 90 m./sec. It was stated that at the height at which meteorites occurred the density of the atmosphere was correlated to surface temperature. It would however appear that this was a seasonal effect. The ratio of the maximum density to the minimum density at those heights was about 3 : 1. Dr. Whipple gave a warning, however, against accepting these results with too much confidence. He pointed out that the values of density deduced depended on the luminosity of the body. If for some reason there was a seasonal variation in the luminosity this would seriously affect the conclusions.

Mr. A. W. Brewer (Great Britain) exhibited an automatically controlled hygrometer based on the design he and Dr. Dobson had evolved. He further gave a lecture on the results obtained by the dew-point hygrometer showing how greatly the water vapour decreased with height above the tropopause. From a rough calculation he estimated that a downward velocity of 50 m./day in the stratosphere would be necessary to maintain the distribution of water vapour if it is assumed that the coefficient of turbulence is about 10^3. This calculation was made on the assumption that there was no advection. Nevertheless the interesting feature is that assuming a not improbable value of the coefficient of turbulence the vertical velocities are of a not improbable value. One further comment may perhaps be allowed. The flights on which Mr. Brewer obtained his information were made mainly in long-track polar air, and hence there is a certain selectivity in the results he has obtained. The information Mr. Brewer gave created a profound effect on the delegates.

An interesting discussion was given by Major Bundgaard (U.S.A.) of the possibilities of statistical forecasting. His method is to take 500-mb. contour maps and submit them to a purely statistical analysis from which he obtains partial regression equations linking temporal and spatial values. From these regression equations it is possible to obtain the most probable future map, and moreover it is possible to obtain from the probable error a measure of the accuracy of the predictions. Major Bundgaard used his method in an attempt to predict the pressure pattern three days ahead, but his system being statistical can only take into account the probable translation of the systems. Development and abnormal deviations cannot be allowed for, and in three days much development may occur. The method if applied as a 24-hr. prontour might produce much more spectacular results.

From the list of notable contributions the two discussions introduced by Sir Nelson Johnson must not be omitted. The first was on the need for more observations of water vapour and of helium in the high atmosphere, and he enumerated from how many angles we were in want of these fundamental facts.

Going on he gave an account of our present knowledge and showed what very serious gaps there were. He urged that individual research workers should concentrate on these problems and develop a technique for their examination as he did not feel that the time was ripe for a mass attack on an international scale. The second discussion centred around antarctic meteorology. Sir Nelson Johnson reviewed the present activity in collecting information from high latitudes. He stated that the International Meteorological Organization had set up a Commission on polar meteorology under the presidency of Dr. Sverdrup and that co-operation was being sought from whaling vessels. He suggested that the International Meteorological Association might seek the co-operation of the International Meteorological Organization in the investigation of the meteorological problems of the Antarctic. He further proposed that workers engaged upon research in the ionospheric field should be invited to participate in the scheme. In the course of the subsequent discussion, the Argentine representative stated that his country was establishing two stations on the Antarctic continent.

The brief notes given above do not cover by any means all the many facets of meteorology which were discussed in the various sessions of the Meteorological Association. They will serve however to show how wide was the range of topics. At the conclusion of the meetings a number of resolutions were adopted by the Meteorological Association which covered among other points the setting up of two sub-commissions, one to be called the Ozone Sub-Commission, the other the Radiation Sub-Commission and names were proposed of persons to sit on these sub-commissions. It was further agreed that a grant should be made from the research vote towards the cost of work on the study of lunar and solar tides in the atmosphere. It was further agreed to adopt Sir Nelson Johnson's suggestion regarding the problem of the Antarctic, and also that the International Meteorological Association should request the International Meteorological Organization to arrange for full meteorological observations, including radio-sonde, to be carried out in any part of the world when mother-of-pearl clouds were observed.

The final plenary Assembly took place on the 28th at which various resolutions were passed by the Union as a whole and reports were made on the activities of the different Associations. The Acting President Prof. N. E. Norlund had asked to be relieved and Prof. Vening Meinesz, Director-General of the Dutch Meteorological Office was elected President for the next three years. Dr. J. M. Stagg was re-elected Secretary and it was announced that the next Assembly, in 1951, should be held in Brussels.

In such an assembly as this the mere narrating of the meetings of the Associations cannot give any idea of the full activities of the Union. It might well be said that more work is done out of sessions than in, for one of the great benefits derived from such meetings is the growth of personal contact at the many social functions with which the delegates were so lavishly entertained.

Notable among the entertainments must be mentioned the Sunday excursion to Lillehammer when almost all the delegates and their friends set out at an early hour in a special train on the 5-hr. journey. This gave ample time for the interchange of opinions—indeed on that train not a few unofficial scientific lectures were given over and above those that figured in the programme of the sessions. The weather did its best to mar the view, and on the motor trip

which the Norwegian Government had planned for us over the mountains there was more opportunity for the study of drop-size distribution than for the measurement of the great ranges of visibility. However an excellent lunch was provided, and we studied (in dripping rain) the early Norwegian houses and the Stave Church of Maihaugen before once more boarding our train and travelling with polyglot babel back to midnight Oslo.

Other pleasant memories are of the reception of British delegates at the Embassy, the fountain and the view over Oslo Fjord and the welcome the Ambassador and Lady Collier accorded us, of " Peer Gynt " performed in a new setting at the National Theatre where our incomprehension of the words gave even greater music to the poetry, of the Vigeland statues in the Frogner Park and the discussions which they aroused, of one glorious evening on the Frognerseter hill with Oslo Fjord to the south and the mountains visible in line on line for 70 miles around, of Oslo port and the little ships that carried us across to visit the *Fram* and the wonderfully preserved Viking ships, and most of all of the fair-haired Norwegians smiling at our efforts to make ourselves understood or, more likely, still smiling, answering us in our own tongue. We owe many thanks to them, members of a small nation who took on themselves our entertainment and laid open all their resources to make the Eighth Assembly of the U.G.G.I. a very notable one.

RECORDS OF SNOW COVER ON SCOTTISH MOUNTAINS

BY GORDON MANLEY, M.A., M.SC.

It is often possible to find in old journals much neglected material of which use can be made in present-day discussions. Recently while looking through the *Journal of the Scottish Meteorological Society* for 1878, I found a short paper* by Alexander Cruickshank of Aberdeen summarising 21 years of daily observations, taken at noon, giving the average frequency with which six hills and mountains visible to the south-west from Aberdeen were " entirely or more than half " covered with snow. The summits were about 5, 10, 20, 25, 35 and 45 miles distant, namely Clochendichter (545 ft.), Cairnmonearn (1,245 ft.), Kerloch (1,747 ft.), Mount Battock (2,555 ft.), Mount Keen (3,077 ft.) and Lochnagar (3,786 ft.). In each case the north-easterly slopes were visible. It is evident that, although the more distant summits are often seen from Aberdeen, assumptions must have been made regarding the persistence of the snow cover during intervals when they were not visible. Cruickshank's earlier paper in the same Journal records that over 21 years Lochnagar was visible from Aberdeen on an average of one day in four.

From the viewpoint, apparently within two miles south of the centre of the city, it appears that reasonable estimates for the mean height of the lower part of the various summits visible are respectively 400, 800, 1,200, 1,600, 2,200 and 2,900 ft. If Cruickshank described the summit in question as " entirely or more than half covered " it would be fair to assume that half or more of the ground was likely to be covered at whatever lower level on the hill might be regarded as " generally visible " from Aberdeen. He also states that half or more of the ground " about Aberdeen " was covered on an average of 25 days per annum between 1857 and 1877.

*CRUICKSHANK, A.; Observations at and near Aberdeen of certain meteorological phenomena. *J. Scot. met. Soc., Edinburgh*, New Series, **5**, 1878, p. 197.

The extremely severe winter of 1878–9, with for example 63 days of snow cover even in the outskirts of Sunderland, is not included in Cruickshank's period ; and for 1857–77 it appears that the mean annual temperature differed little from that of the period 1912–46 for which the mean annual frequency of snow cover at the morning observation was 14·4 at Aberdeen Observatory (80 ft.). For 1925–46 however the mean frequency at Craibstone (300 ft.) was 31 days, although the latter is but 5 miles from the seashore. It is evident that the frequency of snow cover round Aberdeen was much the same as at present, allowing for Cruickshank's viewpoint and the extremely rapid increase as one moves inland to higher ground. Three years' observations at Dyce (240 ft.) give the impression that the mean frequency there would be of the order of 24 days over the past 30 years ; Cruickshank's figure is therefore acceptable for the area " round the city ".

For the various higher levels estimated above, his figures are given in Table I, together with modern data in Table II since the inception of snow-cover observations in the *Monthly Weather Report* in 1912.

TABLE I—AVERAGE ANNUAL NUMBER OF DAYS OF SNOW COVER, 1857-77
(Aberdeenshire)

" Ground more than half covered at noon "		Range of variation
" Round Aberdeen "	25	7–47
At 400 ft.	32	15–55
At 800 ft.	46	21–72
At 1,200 ft.	63	35–99
At 1,600 ft.	92	51–154
At 2,200 ft.	116	71–177
At 2,900 ft.	153	104–200

TABLE II—SOME PRESENT-DAY VALUES

	Height	Period	Average	Range	Authority
	ft.	yr.	days	days	
Craibstone	300	22	31	8–80	*Monthly*
Logie Coldstone	608	15	43†	—	*Weather*
Balmoral	930	35	60	27–116	*Report*
Braemar	1,114	34	67	—	
Drumochter (A. 9)	1,500	—	75	—	Estimated, see
Cairnwell Road (A. 93)	2,200	—	110–120		*Quart. J. R.*
Cairngorm Summits	3,000	—	165	—	*met. Soc., London,*
Ben Nevis	4,406	—*	230	—	**65**, 1939, p. 2

*Based on period 1883–1904. †Approximate.

The agreement of the above figures with present-day values and estimates is evidently good ; it is agreeable to find how well they confirm certain estimates made in my 1939 paper*. In view of drifting it is always rather doubtful just how much of an exposed hill summit will remain covered by snow by comparison with neighbouring slopes and valleys. Cruickshank was in each case looking at the north-east slopes, rather than the actual summits, and from a considerable distance ; but his original and apparently neglected observations deserve bringing to light as an effort to deal with an interesting question of British climatology. Especially they will prove interesting in the light of the efforts made by the Association for Study of Snow and Ice, now the British Glaciological Society, to observe and record the duration of mountain snow cover since 1938†. For example in the mild year 1938 snow cover at

*MANLEY, G.; On the occurrence of snow-cover in Great Britain. *Quart. J. R. met. Soc., London,* **65**, 1939, p. 2.

†MANLEY, G.; Observations of snow-cover on British mountains. *Quart. J. R. met. Soc, London,* **67**, 1941, p. 1.

3,000 ft. was observed on 130 days, a figure comparable with that for the mild year 1868 on Lochnagar.

Cruickshank also noted the days on which snow and sleet fell. Unfortunately he makes separate totals for snow and sleet and it cannot be determined on how many days both forms of precipitation were recorded and distinguished. Direct comparisons cannot therefore be made with modern records, unless some Aberdeen enthusiast finds the original diaries, and we have already a fair picture of the frequency of snow from the Culloden and Edinburgh observations for the period in question. Snow cover was, however, so rarely tabulated by any method comparable with the modern standard that Cruickshank's pioneer effort is noteworthy, especially as we have so little data from the higher summits of the Scottish Highlands.

For the coastal lowland and the highlands respectively it is notable that the winters with the lowest frequency of snow cover are by no means the same ; and the effect of cold springs such as those of 1860 and 1877 in prolonging the upland snow cover is very evident. Near the coast, 1872, 1868 and 1873 were particularly snow-free whereas on the uplands 1857 and 1858 were relatively the least snowy seasons. In the other direction, 1860 and 1867 were snowy near the coast, whereas 1877, 1859 and 1860 were characterised by prolonged cover on the summits. It may be added that for the noticeably snowy year 1947, as many as 59 days were recorded at Aberdeen, 80 at Craibstone and 108 at Braemar. 1947 was therefore very remarkable at low levels near the coast, but was not quite so snowy as 1917 or 1919 at Braemar ; and presumably, therefore, on the mountains above.

The general trend of these observations from Aberdeen can also be checked with the aid of a long record of the frequency of snow cover kept by T. W. Backhouse, on the outskirts of Sunderland, from 1857 to 1915. These in turn can be continued with the aid of the modern data from several north-eastern stations beginning in 1912. While Backhouse's method of observation is again not precisely equivalent to that now adopted his monthly and annual figures can be regarded as broadly applicable for 200 ft. above sea level. It appears that the frequency of snow cover near the north-east coast in 1878–79 (63 days) was closely comparable with that of 1946–47 (about 60 days). The winter of 1916–17 gave about 50 days. No other winter appears to have given more than 40 days although a number gave between 35 and 40, the average being about 14. It is to be hoped that, scattered about the country, other records of the frequency and persistence of snow cover may come to light, from which further estimates of the long-period range of variability of this element may be derived.

BOOKS RECEIVED

Solar variation attending West Indian hurricanes, by C. G. Abbot. Smithsonian Miscellaneous Collections, Vol. 110, No. 1. Size: 9½ in. × 6¼ in., pp. 7. Washington, D.C., 1948.

1947–1948 *Report on the* 27·0074-*day cycle in Washington precipitation*, by C. G. Abbot. Smithsonian Miscellaneous Collections, Vol. 110, No. 4. Size: 9½ in. × 6½ in., pp. 2. Washington, D.C., 1948.

Smithsonian pyrheliometry and the standard scale of solar radiation, by L. B. Aldrich and C. G. Abbot. Smithsonian Miscellaneous Collections, Vol. 110, No. 5. Size: 9½ in. × 6½ in., pp. 4. Washington, D.C., 1948.

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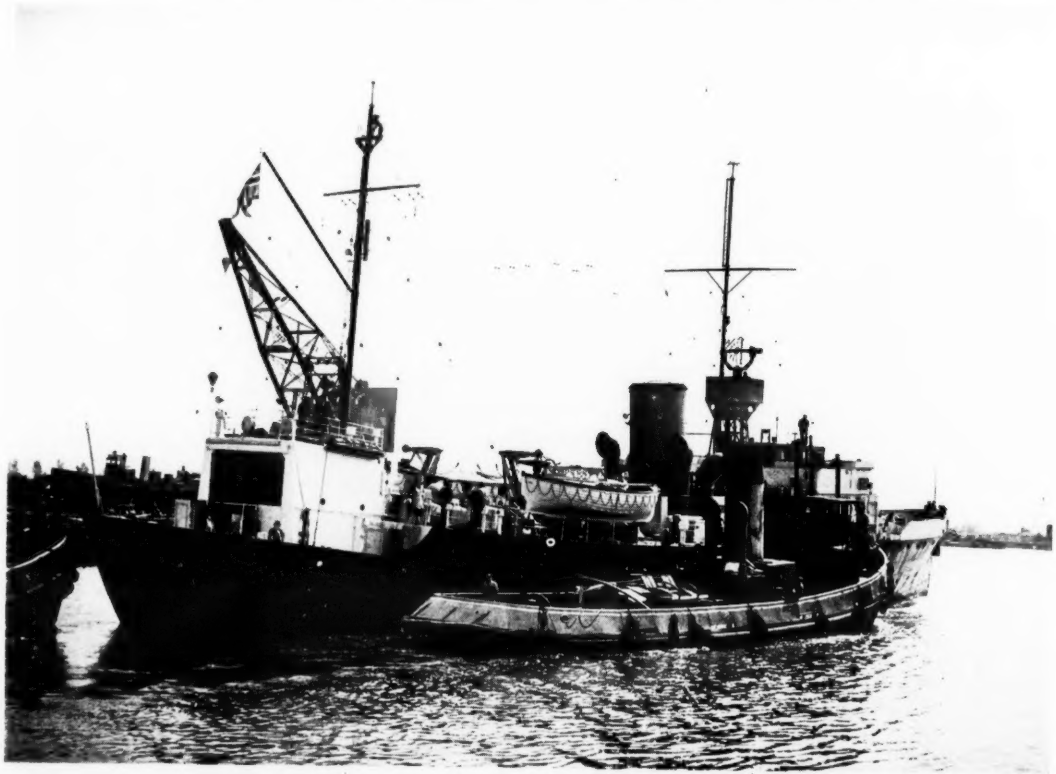

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O.W.S. *Polarfront I* LEAVING CHATHAM NAVAL DOCKS, MAY 22, 1948

The *Polarfront I* and *Polarfront II* are manned by Norwegians and operate at station M (66°N. 2°E.), which is the joint responsibility of Great Britain, Norway and Sweden.

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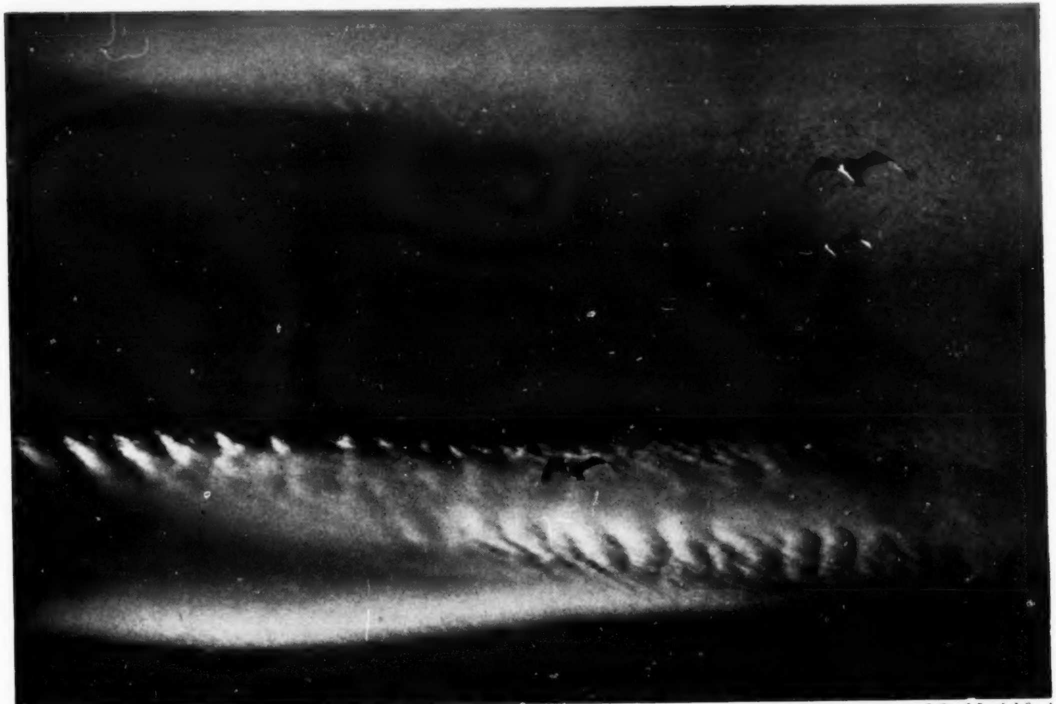

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ALTOCUMULUS AND CIRROCUMULUS LENTICULARIS

Photograph taken from the *Weather Recorder* off Rathlin Island about 1600 G.M.T., July 25, 1948

USE IN AGRICULTURAL METEOROLOGY OF TABLES FOR GREAT-CIRCLE SAILING

BY N. CARRUTHERS, B.SC.

An important problem in agricultural meteorology is that of determining angles of incidence of the sun's rays upon a sloping hillside, at a place S (say), at different times of the day. P. J. H. Unna, in a letter to *Nature** shows that the computations involved are greatly simplified by the use of Towson's tables.† The present note is a more detailed account of the method outlined by Unna in *Nature*.

Suppose that the hillside in question, at S, approximates to a plane surface inclined to the horizontal at an angle β and that the vertical plane through the line of greatest slope ‡ makes an angle α with the north-to-south direction. Unna terms α the " aspect " of the slope.

Fig. 1 represents the great circle of the earth in the plane of the line of greatest slope at S, C being the centre of the earth. The slope at S is in the direction SD, and T is the point of contact of the (nearer) tangent plane parallel to SD. From the cyclic quadrilateral, KTCS, it is easily seen that the great-circle arc, TS, subtends an angle β at C. Since the mean circumference of the earth is very nearly 21,600 nautical miles, the length of TS in nautical miles may be expressed as 60β, where β is measured in degrees.

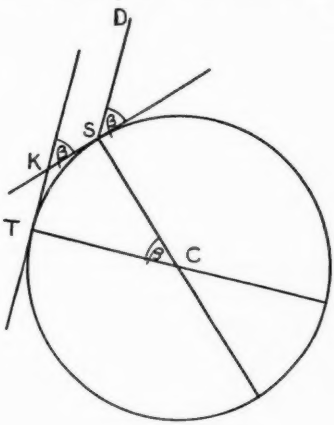

FIG. 1

The sun may be presumed to be at an infinite distance, and so the angle of incidence (but not the intensity) of the sun's rays on the slope SD at S will be equal to that on a horizontal surface (TK) at T, at exactly the same time. Thus, if the position of T is known, the usual tables giving elevation of the sun at T can be used for the sloping hillside at S, the only correction necessary being that of expressing the time at T in terms of local (or standard) time at S when T differs from S in longitude.

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*UNNA, P. J. H.; Angle of incidence of sun's rays. *Nature, London*, **160**, 1947, p. 713.

†TOWSON, J. T. and ATHERTON, J. W.; Tables to facilitate the practice of great circle sailing. London, 6th edn., 1916.

‡This plane is shown as DFG in Fig. 2, p. 276.

The problem has therefore been resolved into that of finding a point T distant 60β miles from S along the great-circle course which makes an angle α with the north-south line at S. The method of deriving the latitude and longitude of T from Towson's tables is outlined below and a simple example is given in detail. T lies to the north or south of S according to whether the slope at S faces north or south.

Let ϕ_S and ϕ_T be the latitudes of S and T and let λ be the difference in longitude between them. In the simple case in which the aspect of the slope at S is due north or south, T is in the same longitude as S and differs in latitude by exactly β. For a slope towards the equator, when $\alpha = 0$,

$$\lambda = 0, \quad \phi_T = \phi_S - \beta.$$

If $\beta > \phi_S$, ϕ_T becomes negative and T lies in latitude $\beta - \phi_S$ in the opposite hemisphere to S. For a poleward slope, when $\alpha = 0$,

$$\lambda = 0, \quad \phi_T = \phi_S + \beta.$$

This rule is quite simple so long as β does not exceed $90^\circ - \phi_S$. If $\beta > 90^\circ - \phi_S$, the rule still holds but T is found to lie on the opposite side of the pole to S and its position is given more conveniently by :

$$\lambda = 180^\circ, \quad \phi_T = 180^\circ - (\phi_S + \beta).$$

When α is not zero, T can be found by Towson's tables as described below.

Method of computation.—Let ϕ_V be the latitude of the vertex, V, of the great circle through S and T. The differences in longitude between S and V and T and V may be denoted by λ_S and λ_T so that λ is either the sum or difference of λ_S and λ_T.

Towson's tables are arranged in 89 major columns each of which refers to a great circle. The latter is specified by the latitude of its vertex ; that is, by its point of maximum latitude. Each major column is divided into three minor columns giving latitude, direction of course, and distance (along the great circle) from the vertex. The first step, in finding ϕ_T and λ is to pick out the major column, ϕ_V in which latitude ϕ_S corresponds most closely to " course " α. It is evident that ϕ_V will always be greater than ϕ_S except when $\alpha = 90^\circ$. When $\alpha = 90^\circ$, S coincides with V because a great circle runs east and west only at its points (one in each hemisphere) of maximum latitude. Interpolation between major columns to get a more exact value of ϕ_V is unnecessary, for even a difference of a whole degree in ϕ_V makes no appreciable difference to the values obtained subsequently for ϕ_T and λ (see Table I).

In the major column ϕ_V the line is found in which " Lat." and " Course " are as nearly as possible equal to ϕ_S and α respectively. D_S, a rough approximation to the distance of S from V, is extracted from the minor column labelled " Dist." and λ_S from the side column " Longitude from the vertex." It is as well to give λ_S to the nearest half degree, D_S being taken as the mean between two successive values of " Distance " where necessary. Finer linear interpolation is needed only when λ_S approaches 90° where the difference in latitude between successive lines of the table exceeds 2°.

The next step is to find D_T, the approximate distance of T from V. If the slope at S faces equatorwards, 60β is added to D_S to give D_T ; if the slope faces polewards, 60β is subtracted.

In the same major column ϕ_V as before, the line is found in which the "distance" is D_T' such that, as nearly as possible,

$$\begin{aligned} &\text{when } D_T \text{ is negative, } D_T' = -D_T \\ &\text{when } D_T \text{ is positive and less than 5,400, } D_T' = D_T \\ \text{and } &\text{when } D_T \text{ exceeds 5,400, } D_T' = 10{,}800 - D_T \end{aligned}$$

Where necessary D_T' may be taken as the mean of the "distances" in two consecutive lines, and finer linear interpolation may be required between the last few lines of the table. The entry under "Lat." in the line determined is ϕ_T, which should be rounded off to the nearest whole degree ; and the entry in the side column, "Longitude from vertex," is λ_T which is required to the nearest half degree.

The difference in longitude, λ, between S and T is found from the sum or difference of λ_S and λ_T. When D_T is positive, S and T lie on the same side of the vertex and $\lambda = \lambda_S \sim \lambda_T$; when D_T is negative they lie on opposite sides and $\lambda = \lambda_S + \lambda_T$. It is not difficult to decide whether λ should be added to or subtracted from the longitude at S to give the longitude of T : for an easterly facing slope, T lies to the east of S ; for a westerly, to the west of S.

The latitude of T is given directly by ϕ_T. If D_T exceeds 5,400, and this is possible only when ϕ_S is less than β, T is on the opposite side of the equator to S and ϕ_T refers to the opposite hemisphere. As a matter of interest it may be remarked that a slope with a southerly aspect in the northern hemisphere does not necessarily get more sun than a horizontal surface : if $\beta > 2\phi_S$, for values of α near 0°, the latitude of T will be greater than that of S.

TABLE I—EXTRACT FROM TOWSON'S TABLES

LATITUDE OF VERTEX									Longitude from vertex
75°			76°			77°			
Lat.	Course	Dist.	Lat.	Course	Dist.	Lat.	Course	Dist.	
° ′	° ′	′	° ′	° ′	′	° ′	° ′	′	°
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..
50 33	24 3	2216	52 31	23 30	2105	54 37	22 57	1989	71
49 5	23 17	2312	51 3	22 43	2200	53 10	22 9	2082	72
47 30	22 32	2415	49 29	21 58	2301	51 38	21 21	2181	73
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..
40 1	19 46	2896	42 23	19 1	2780	44 22	18 18	2655	77
37 48	19 9	3036	40 13	18 22	2922	42 12	17 37	2797	78
..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..

Summary of computation method

(1) Column ϕ_V is that in which ϕ_S under "Lat." corresponds to α under "course" ($\phi_V \geqslant \phi_S$).

(2) D_S is the "Distance," in column ϕ_V, corresponding to ϕ_S, and λ_S is the corresponding "longitude from the vertex".

(3) For southerly aspects (northern hemisphere), $D_T = D_S + 60\beta$; for northerly aspects (northern hemisphere), $D_T = D_S - 60\beta$.

(4) ϕ_T (nearest whole degree) is the latitude, in column ϕ_V, corresponding to "Dist." D_T if $|D_T| < 5{,}400$, or corresponding to distance $10{,}800 - D_T$ if $D_T > 5{,}400$; and λ_T is the corresponding "Longitude from the vertex".

(5) λ is the sum or difference of λ_S and λ_T according to whether D_T is negative or positive. For easterly (westerly) aspects, T lies to the east (west) of S; and, if $\lambda = H$ hours, sunrise and sunset are H hours earlier (later) at T than at S.

Example.—It is required to find the position of T corresponding to a slope of 1 in 5, facing south-south-east in latitude 52°. This slope (at the place S) is shown diagrammatically in Fig. 2, DG being the line of greatest slope.

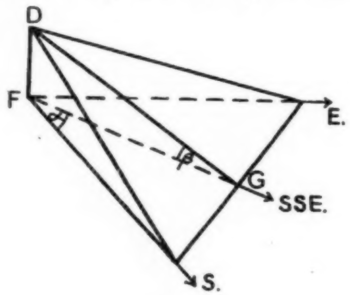

FIG. 2

Here, $\alpha = 22\frac{1}{2}°$ (the angle between south and south-south-east), $\phi_S = 52°$N. and $\tan \beta = DF/FG = 1/5 = 0{\cdot}2$, i.e. $\beta = 11°19' = 679'$.

We know that ϕ_V is greater than 52°: opening the tables at random, I find that, for $\phi_V = 80°$ (heading of column), 62°44′ under "Lat." corresponds to 22°16′ under "course" and 51°59′ under "Lat." corresponds to 16°23′ under "course". We require $\phi_S = 52°$ to correspond to $\alpha = 22\frac{1}{2}°$. Moving back through the table, we find the combinations shown in Table I.

Our best choice appears to be $\phi_V = 76°$, and the line showing latitude 51°3′. Corresponding to this latitude, we find $D_S = 2{,}200$ and $\lambda_S = 72°$.

The aspect is southerly, and so
$$\begin{aligned} D_T &= D_S + \beta \\ &= 2{,}200 + 679 \\ &= 2{,}879 \end{aligned}$$
where β, D_S, D_T are all expressed in minutes of arc or nautical miles.

Running down the same column, $\phi_V = 76°$, possible values for D_T are 2,780, 2,852 (halfway) or 2,922, and the nearest to D_T is 2,852. The other figures taken halfway between the lines give $\phi_T = 41°$ and $\lambda_T = 77\frac{1}{2}°$, and so, D_T being positive,
$$\begin{aligned} \lambda &= \lambda_T - \lambda_S \\ &= 77\tfrac{1}{2}° - 72° \\ &= 5\tfrac{1}{2}°. \end{aligned}$$

The aspect of the slope at S is easterly and therefore T is a place in latitude 41°N., $5\frac{1}{2}°$ longitude further east than S. The apparent noon on the slope at S is about 22 minutes before midday.

The stages of computation of ϕ_T and λ for a slope of 40° in latitude 46°N. are given in Table II. These values of ϕ_T and H (longitude expressed in hours) agree quite well with those given by P. J. H. Unna (shown in parenthesis) and appear sufficiently accurate for agricultural purposes.

TABLE II—COMPUTATION OF THE CO-ORDINATES OF T FOR A HILL SLOPE OF INCLINATION 40° IN LATITUDE 46°N.

Symbols with suffix letters S, T and V refer to values at S, T and V; λ and H are difference in longitude between S and T in degrees and hours respectively.

$\phi_s = 46°$, $\beta = 40°$, i.e. $60\beta = 2{,}400$

α	0	10	20	30	40	50	60	70	80	90
ϕ_V	90	83	76	70	63	58	53	49	47	46
λ_s	—	83	75	67½	58½	49	39	27	14	0
D_s	—	2627*	2525	2373	2192	1882	1559	1109	579	0
Southerly aspect										
D_T	—	5027	4925	4773	4592	4282	3959	3509	2979	2400
D_T'	—	5027†	4907	4773†	4618	4296	3960	3502	2985	2407
ϕ_T	6	6†	8	10†	12	15½	19	23	28	33
ϕ_T (Unna)	(6)	(7)	(8)	(10)	(12·5)	(15·5)	(19)	(23)	(28)	(33·5)
λ_T	—	89½	88	86½	84	80	75	68	60	50½
λ	0	6½	13	19	25½	31	36	41	46	50½
H	0	0·4	0·9	1·3	1·7	2·1	2·4	2·7	3·1	3·4
H (Unna)	(0)	(0·4)	(0·85)	(1·25)	(1·65)	(2·05)	(2·45)	(2·75)	(3·0)	(3·35)
Northerly aspect										
D_T	—	+227	+125	−27	−208	−518	−841	−1291	−1821	−2400
D_T'	—	227	125	21	205	518	840	1291	1840	2407
ϕ_T	86	82	76	70	63	57	51	45	39	33
ϕ_T (Unna)	(86)	(81·5)	(76)	(70)	(63·5)	(57)	(51)	(45)	(39)	(33·5)
λ_T	—	28½	8½	1	7½	16	22½	31	41	50½
λ	0	54½	66½	68½	66	65	61½	58	55	50½
H	0	3·6	4·4	4·6	4·4	4·3	4·1	3·9	3·7	3·4
H (Unna)	(0)	(3·65)	(4·35)	(4·55)	(4·5)	(4·3)	(4·1)	(3·85)	(3·65)	(3·35)

*D_s interpolated linearly with respect to ϕ_s
†ϕ_T interpolated linearly with respect to D_T

EFFECT OF HOUSE-BLOCKS OF TOWNS ON THE FALL OF TEMPERATURE AT NIGHT

By D. BERÉNYI, Ph.D.
(Professor at the Meteorological Institute of the University of Debrecen, Hungary)

In the March 1948 number of the *Meteorological Magazine*, Mr. W. A. L. Marshall* deals with the effect of the building, containing the Meteorological Office, on the maximum and minimum temperatures read in a Stevenson screen on its roof by comparison with " open space " data from Kensington Palace Gardens.

I dealt with a similar subject by other methods and from a different point of view in an article† published in the Hungarian periodical *Időjárás* in 1930.

I compared 476 minimum temperatures read at two points in the town of Debrecen. One of these points was on the fourth floor (height 20 m.) of a building in the centre of the town and the other in an open space 3 Km. from the centre of the town. The observations were made every night from August 1928 to December 1929.

My aim was the investigation of the effect of the heat radiation of the houses on the fall of temperature at night and on the factors influencing this effect.

*MARSHALL, W. A. L.; London temperatures. *Met. Mag., London*, **77**, 1948, p. 54.
†BERÉNYI, D.; A városi háztömbök hatása az ejjeli lehűlésekre. *Időjárás, Budapest*, **34**, 1930, p. 46.

The method used was to correlate the difference in the minimum temperatures at the two places with the mean cloudiness and wind velocity using averages of the 9 p.m. and 7 a.m. local mean time observations.

The results of the comparison are given in Table I.

TABLE I—AVERAGE DIFFERENCE OF NIGHT MINIMUM TEMPERATURES

Mean cloudiness	Wind speed (m./sec.)			
	0·0–1·0	1·1–2·4	2·5–5·0	>5·0
tenths	°C.	°C.	°C.	°C.
0·0– 2·0 ..	3·7 (56)	2·1 (40)	1·5 (19)	0·2 (13)
2·1– 4·0 ..	2·9 (14)	2·2 (18)	1·4 (13)	0·7 (7)
4·1– 6·0 ..	2·1 (26)	2·3 (33)	0·9 (18)	0·8 (14)
6·1– 8·0 ..	1·8 (13)	1·1 (13)	0·5 (26)	0·2 (10)
8·1–10·0 ..	1·0 (44)	0·8 (39)	0·8 (39)	0·1 (16)

Number of observations shown in brackets.

The observations definitely showed that as cloudiness and wind speed increased the average differences in the two minima decreased, the increase in wind speed having a greater effect than increase in cloudiness.

Table II shows the effect of cloudiness and wind speed separately.

TABLE II

Mean cloudiness (tenths)	0·0–2·0	2·1–4·0	4·1–6·0	6·1–8·0	8·1–10·0
Difference in minimum temperature (°C.) ..	2·6	2·0	1·7	0·8	0·8
No. of observations ..	128	52	91	67	138
Mean wind speed (m./sec.)	0·0–1·0	1·1–2·4	2·5–5·0	>5·0	
Difference in minimum temperature (°C.) ..	2·4	1·7	0·9	0·4	
No. of observations ..	153	148	115	60	

With clear sky and light wind the average difference was 3·7° to 6·7°C. but on one occasion the difference was as high as 6·7°C. and on 23 occasions exceeded 5°C.

According to Mr. Marshall's table (p. 57) the difference between the Victory House roof and Kensington Palace Gardens reached 10°F. (5·5°C.) which agrees quite well with the differences found in Debrecen.

[Night minimum temperature differences of more than 9°F. between the ground and 20 m. were much more frequent at Debrecen on the nights examined by Prof. Berényi than between the ground and about 40 m. in London over the year August 1946–July 1947. The extreme differences at the two places were about the same. This is probably because Prof. Berényi's observations were made over a 16-month period including one whole winter and part of a second.

An adequate comparison cannot be made without further details of the "fourth-floor" thermometer exposure.—W. A. L. MARSHALL]

METEOROLOGICAL OFFICE DISCUSSION

The first discussion of the 1948–9 series was held in the Imperial College on Monday September 27, 1948. Dr. Frith introduced the paper " Production

of rain by chain reaction in cumulus clouds at temperatures above freezing " by Irving Langmuir.*

In any cloud if there are some drops larger than average, these drops will fall. Under suitable conditions they will grow by coalescence, until they reach the limiting (breaking-up) size. The rate at which these drops grow depends upon their size and the nature of the cloud through which they fall. But it depends also upon the " efficiency of catch ". Langmuir, using formulæ calculated with the aid of a differential analyser, develops tables, largely empirical, showing the efficiency of catch of a drop of radius S falling through a cloud of particles of radius r. (He assumes throughout that there is no " bounce-off " of droplets.) From these tables he calculates the conditions under which the drop will grow to the limiting size.

Next Langmuir studies the effect of a vertical current. Consider a falling drop which breaks up into smaller drops at a level z_0. If the vertical current is greater than the falling velocity of the resulting fragments, these will ascend. The fragments, being still large compared with the size of the cloud particles, will grow as they ascend. If they, in turn, split up before they have descended to the level z_0, then a chain reaction will have commenced and the number of large drops in the cloud will increase. The accumulation of large drops will eventually cause a down-draught, which will be compensated by increased turbulence in other parts of the cloud. Moreover the loss of quantities of water will decrease the density of the cloud and may, consequently, result in increased vertical development.

This theory is applied to an experiment in the Hawaiian Islands. A cumulus cloud with base at 2,500 ft. and top at 8,700 ft. (freezing level at 15,000 ft.) was seeded with crushed dry ice. Within 9 min. rain began and spread over a considerable area; two hours later the cloud had developed to over 15,000 ft. Langmuir deduced that the vertical currents must have been at least 600 cm./sec.

Dr. Frith then gave an account of " Operation Cirrus ", Langmuir's work on the artificial nucleation of clouds.†

After discussing laboratory experiments on the production of ice crystals in a cloud of supercooled water droplets, Langmuir describes a series of experiments in which crushed dry ice was dropped into natural supercooled clouds. He states that the results of such experiments were always spectacular: the portion of the cloud " seeded " changing quickly into an ice-crystal cloud and slowly subsiding, sometimes leaving a completely cloud-free " lane ", the effect spreading sideways at about 3 m.p.h.

In addition to describing these experiments, Langmuir discussed the use of silver iodide as a *nucleating* agent, and he spoke also of the possibility of (*a*) making rain, (*b*) clearing paths for aircraft through icing conditions.

On these last two points Dr. Frith emphasised that (*a*) none of the experiments of Operation Cirrus, as described by Langmuir, had produced any significant amount of rain, and (*b*) there was no report of paths being cleared through such clouds as altostratus or cumulonimbus (in which the most serious icing is found).

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*Published by the General Electric Research Laboratory, Schenectady, N.Y., 1948.

†LANGMUIR, I. and others; First quarterly progress report, Meteorological research, 1 March—1 June 1947. Washington, D.C., 1947.

In the discussion which followed, Sir Nelson Johnson referred to the fact that the particles in any cloud are never of uniform size. There are always a few larger ones. One might therefore query the necessity for the artificial introduction of large particles to set off a chain reaction. With regard to the second paper Sir Nelson spoke of a discussion on the artificial production of rain at the meeting of the U.G.G.I. at Oslo recently. Dr. Reichelderfer, Head of the United States Weather Bureau, had deplored the sensational claims which had been made with regard to rain-making and had pointed out that, in every case in which Langmuir's team had made rain, it had been raining naturally within 30 miles.

Mr. Absalom referred to the question of coalescence of drops and pointed out that laboratory workers, working it is true with drops of 1 or 2μ, had never observed coalescence.

Mr. Ludlam suggested that the initial large drop, required to set off a chain reaction naturally, could arise by normal condensation processes since the vapour pressure over a large drop is less than over a small drop; so that, in time, any drop which had initial advantage would grow at the expense of smaller drops.

Dr. Scrase remarked that Langmuir had not taken into account the effect of an electric field, or of electric charges on the drops.

Prof. Sheppard emphasised the value of Langmuir's work, whilst agreeing that the economic value of rain-making might have been exaggerated. He tnought that although Langmuir's figures might in places be in error, there was no reason to suppose that the ideas might not be fundamentally sound.

Dr. Sutcliffe remarked that what most meteorologists would want to know was to what extent Langmuir's work influences current ideas. He suggested that there was nothing in the work inconsistent with the generally accepted idea that most raindrops originate as ice crystals. With regard to the second paper Dr. Sutcliffe suggested that most clouds, if made to precipitate completely out, would provide only insignificant amounts of rain.

In reply, Dr. Frith agreed with Dr. Sutcliffe's conclusions in so far as this country is concerned, but remarked that the chain-reaction process might be the rule rather than the exception in some tropical regions. Whilst it is true that the amount of water in most clouds is not sufficient to give a significant rainfall if precipitated out, there are three points to be borne in mind: (*a*) there is some merit merely in clearing cloud, (*b*) Langmuir referred to the possibility of a self-generating cloud resulting from a seeding process, and (*c*) in orographic cloud, seeding might result in copious and prolonged rainfall.

METEOROLOGICAL RESEARCH COMMITTEE

The 55th meeting of the Meteorological Research Committee, a joint meeting with the Aeronautical Research Council, was held on October 12. At this meeting the nature of the meteorological information required by the designers and operators of aircraft was reviewed and the extent to which existing information is inadequate was examined. The general conclusions were that statistical information about winds and temperatures at greater heights and over the whole globe is required, that further information about turbulence is needed in connexion with the stresses imposed on aircraft and that more quantitative

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ALTOCUMULUS AND CIRROCUMULUS LENTICULARIS

Photograph taken from the *Weather Recorder* off Rathlin Island, about 1600 G.M.T., July 25, 1948

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Reproduced by courtesy of O. M. Ashford

IN THE REAR OF A COLD FRONT

Photograph taken at 2030 G.M.T. at station JIG, July 18, 1948

information is necessary about the concentration and form of liquid water in the atmosphere at sub-freezing temperatures in connexion with de-icing problems.

The 4th meeting of the Physical Sub-Committee was held on October 21. Papers considered included *Met. Res. Publ.* No. 424, by Mr. F. Pasquill, which deals with temperature and humidity gradients in the lowest two metres of the atmosphere and discusses the evaluation of evaporation from a grass-covered surface. Two papers by Mr. J. K. Bannon (*Met. Res. Publ.* Nos. 436 and 437) were also discussed. These two papers deal with the occurrence of clear-air turbulence at high altitudes and suggest that a major factor in the occurrence of this phenomenon may be wind shear in the horizontal.

OFFICIAL PUBLICATIONS

The following publication has recently been issued :—

GEOPHYSICAL MEMOIRS

No. 81. *The aurora of January* 25 *to* 26, 1938 *and associated magnetic storm.* By F. E. Dixon, B.A.

The auroral display of January 25 to 26, 1938, was the most spectacular for many years, and the associated disturbance of the earth's magnetic field was of exceptional severity. This memoir, the publication of which was delayed by the war, summarises the available observations of both classes of phenomena and relates them to solar conditions.

Estimates of their positions show that the principal auroral arcs were about 90 Km. above the earth. One of these arcs extended from the Baltic to at least 200 Km. west of Ireland. The rays reached heights exceeding 500 Km.

Other features discussed are electric-current systems in the upper air over the British Isles at the time, and the question as to whether or not any sounds can be identified as due to the aurora.

Illustrations include reproductions of magnetograms and two attractive plates of the aurora, one depicting it as seen from the Mediterranean.

LETTERS TO THE EDITOR

Variation of temperature in a free-water surface

The article by Mr. Stormonth in the August number, on variations of temperature in a free-water surface, brings to the foreground a question of great interest and importance to all meteorologists—perhaps especially from the synoptic viewpoint. Although the measurements concerned were taken in idealised conditions—in perfectly still water—the gradients concerned are of such a magnitude that it makes one wonder what the readings would be in relatively calm water at sea.

Observations have shown that very considerable horizontal gradients do occur at sea, not only at margins (fronts) of widely differing currents (e.g. the Gulf Stream and Labrador current) but also in almost any part of the ocean. These gradients (casual, variable or constant though they be) may be due to upwelling of a body of cold water, to variations in density, to the confluence of varying currents at different depths, or to local heating by the sun. It is certain that these gradients are sometimes quite steep. Anyone who has bathed off

the British coast will have experienced these temperature gradients close in-shore.

A vertical gradient in the upper 10 m. of the sea is also of considerable interest to the meteorologist; the skin surface temperature, being that with which the air mass under consideration is in contact, is that in which he is primarily interested, but it is rarely that he is able to obtain that.

The methods employed at sea for obtaining the water temperatures are:—

(*a*) The bucket method, whereby a sample of water is obtained from a bucket lowered over the side, the thermometer being immersed in the water after the bucket has been hauled on deck. In this case, the water is probably obtained from a mean depth of about 1 ft. below the surface.

(*b*) The intake method, whereby the temperature of the water flowing to the condenser is measured. The intake itself may be anything from 10–30 ft. below the surface.

It seems probable, but not certain, that in rough weather so much mixing takes place, that there is practically no gradient in the upper part of the 10 m. layer, but even 20 ft. is a fair depth and it is doubtful if much disturbance takes place at this depth (except, say, with a force 7 wind).

In very calm weather, it seems that very little mixing will take place at sea, and in such conditions on a hot, sunny day, it seems that a very appreciable vertical gradient may exist. A ship moving through the water will, it seems certain, stir the water up to a considerable extent and observations taken from the ship, whether from the bucket or the intake, will presumably indicate a mean temperature of the " block " of water concerned. It seems that this will not be the temperature of the skin surface of the water, which is presumably what the meteorologist desires.

This problem was quite extensively discussed at the recent International Meteorological Organization meetings at Toronto, by both Commissions for Maritime Meteorology and for Instruments and Methods of Observation. It could not be decided whether the bucket method (assuming an insulated bucket is used and errors are thereby reduced to a minimum) or the intake method was preferable. Quite apart from the gradient problem, both methods have distinctive practical limitations and liability to error. It was, however, decided that the problem needed investigating, and countries operating ocean weather ships were asked to co-operate.

The British ocean weather ships are fitted with thermographs in the intake at about 12-ft. depth, and comparisons with " bucket " readings are made. Arrangements are also being made to take sea-water observations from rubber dinghies away from the ship.

Attempts to investigate these problems were made, at the request of the Marine Branch of the Meteorological Office, aboard certain merchant ships in the North Atlantic during the war, and a large number of comparative readings between intake and bucket methods were made. The results were found to be extremely variable, however, and no exact conclusions could be reached, apart from the fact that the canvas bucket which was then in use was an unreliable apparatus.

C. E. N. FRANKCOM

October 2, 1948

Aurora

I should like to put on record some observations of the aurora made on the north-east coast of Ireland two miles north of Donaghadee at about 2300 G.M.T. on the nights of September 29–30 and October 3–4 and 4–5, 1948. On all three occasions there was a steady glow, yellowish in colour, and not unlike the glow to be seen when the sun is a few degrees below the horizon in cloudless weather. This glow had roughly the shape of a segment of a circle, with the highest point directly under the pole star. In that direction (i.e. approximately true north) there was open sea for more than 50 miles, and the only large town that might possibly have caused a glow in the sky was Belfast, which lay in a west-south-west direction well outside the area of the glow. On the first of the three occasions three faint rays could be seen, extending beyond the glow and roughly perpendicular to its upper " boundary " if such a word can be used for anything so vague.

E. V. NEWNHAM

October 11, 1948

NOTES AND NEWS

Sir Napier Shaw Memorial

The Royal Meteorological Society has recently decided to establish a Memorial Fund to endow a " Napier Shaw Award of the Meteorological Society ". It is hoped that the Fund will be sufficiently well supported to permit the foundation of a post-graduate scholarship tenable anywhere within the British Commonwealth.

The Council of the Royal Meteorological Society has circulated an appeal to its members, but it is thought that there may be many people who are not members of the Society who would like to associate themselves with this scheme. The pre-eminent position occupied by Sir Napier Shaw in laying the scientific foundations of meteorology, his long connexion with the Meteorological Office (1897–1919) and his world leadership as President of the International Meteorological Organization, are factors which should make this appeal of interest to a very wide field.

I am authorised by the President of the Royal Meteorological Society to say that it is not intended to restrict this scheme within the membership of the Society, and that contributions from other sources will be welcomed. They should be sent to the Executive Secretary of the Royal Meteorological Society at 49 Cromwell Road, London, S.W.7.

N. K. JOHNSON

The variability of means of a series of observations

It is well known that in a random series of observations of standard deviation σ, the standard deviation of the means of n successive values is given by $\sigma/\sqrt{n}$. If the series is not random, but has " persistence ", this simple rule no longer holds.

Let $x_1 \ldots x_p \ldots x_n$ be a series of observations with standard deviation σ, and a correlation r between successive values. Then, if σ_2 be the standard deviation of means of pairs of values,

$$\sigma_2^2 = \sum_{p=1}^{n-1} \tfrac{1}{4}(x_p^2 + x_{p+1}^2 + 2x_p x_{p+1})/(n-1)$$

$$\Sigma x_p x_{p+1}/(n-1) = r\sigma_1^2$$

and therefore $\sigma_2 = \sigma_1 \sqrt{\left(\frac{1+r}{2}\right)}$ .. (1)

In theory, if the correlation coefficient of successive terms is r, that between terms p and $p + n$ should be r^n. Then if σ_n be the standard deviation of means of n successive values

$$\sigma_n = \sigma_1 \sqrt{[n + 2\{(n-1)r + (n-2)r^2 + \ldots + r^{n-1}\}]/n} \quad .. (2)$$

To test this expression, daily pressure readings at Kew for October 1938 to March 1939 were expressed as differences from the average for the whole series, and then combined in means of successive sets of 2, 3, 4, 6, 8, 12, 16. The standard deviation of the individual observations was 10·67 mb. and the autocorrelation coefficient 0·667. The standard deviations of the various sets are shown by the crosses in Fig. 1, while the smooth curve shows the values calculated by expression (2). It is seen that the crosses lie entirely above the smooth curve, i.e. the standard deviations given by expression (2) are too small.

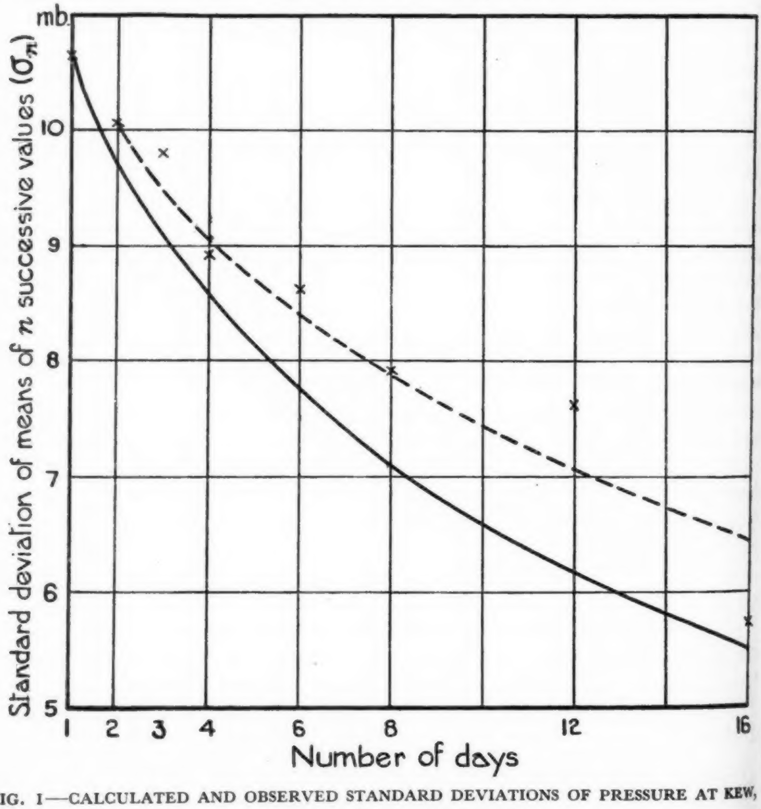

FIG. 1—CALCULATED AND OBSERVED STANDARD DEVIATIONS OF PRESSURE AT KEW, OCTOBER 1938 TO MARCH 1939

This is obviously because, in meteorological series, "persistence" is not constant but increases with time. If pressure is high on one day, there is a good chance that it will be high on the second day, but if pressure has been high on two successive days, the probability that it will be high on the third day is increased, and so on. Consequently a new series of standard deviations were calculated, beginning with that for the mean of two successive days, and using the autocorrelation coefficient r_2 between successive means of two days, which was 0·624. The result is shown by the broken line in Fig. 1, which is a reasonably good fit for the observations. With only 182 days, the numbers of successive means of 12 and 16 days are only 15 and 11 respectively, so that the observed standard deviations naturally show a good deal of scatter.

It may be remarked that for independent observations with standard deviation 10·67 mb., σ_{16} would be only 2·67 mb., so that the effect of day-to-day persistence is quite marked over half a month. With means over still longer periods, the effect of persistence gradually decreases.

C. E. P. BROOKS

WEATHER OF OCTOBER 1948

During the first three days of the month pressure was rather high over England while an anticyclone was moving away across northern France. A new anticyclone reached England from the west on the 5th, but soon moved away eastwards, and for about a week the British Isles lay between large depressions to the west and north-west, and anticyclones to the east or north-east. Between the 17th and 18th a secondary depression moved north-eastwards across England, and on the 22nd a large and very deep depression, moving at about 40 m.p.h. passed eastwards across the Faeroes, reaching Finland early on the 23rd. Another depression moved north-eastwards across the Hebrides on the evening of the 24th, but pressure became rather high after the 25th, at first as a result of a wedge connected with an anticyclone over the Azores and then owing to the development of a large anticyclone centred over Scandinavia, with pressure 1040 mb. near the centre from the 29th to the 31st.

Monthly mean pressure was above 1020 mb. in the states of Virginia, Ohio and Pennsylvania, in the Azores, and from central Europe across to the Black Sea, and was 1000 mb. in the south-west of Iceland. It was 5 to 10 mb. below the average for October in north-east Greenland, northern Scandinavia, Finland and north-west Russia, and generally slightly above the average in the U.S.A., in the Azores, in the British Isles, and from France to the western frontiers of Russia.

In the British Isles the weather was changeable; mild weather prevailed until the 25th, apart from a cool spell around the 4th to 6th but it was cold from the 26th onwards. The month was unusually wet in the west of Scotland but dry over most of England and Wales. Exceptionally severe gales occurred in the extreme north of Scotland on the 22nd and 25th.

During the opening days an anticyclone over southern England and northern France moved slowly east-south-east. Meanwhile secondary troughs of low pressure moved north-north-east along our north-west seaboard causing rain in the west and north, which was heavy in the west of Scotland on the 1st (3·60 in. at Ardgour, Argyllshire and 2·72 in. at Fort William). Subsequently an anticyclone moved slowly east across the British Isles and a spell of mainly

fair weather prevailed apart from some rain in the south-west on the 6th. By the 8th a complex area of low pressure covered the North Atlantic and troughs of low pressure approached our western districts; strong winds and gale locally occurred on the north-west coasts and considerable rain fell in Scotland and Ireland, many stations in Scotland recording more than 2 in. of rain on the 9th. In England and Wales conditions continued fair. On the 11th a small secondary depression moved north-east from the south-west of Ireland; rain occurred fairly generally on the 11th and thunderstorms were widely recorded in the south-east on the 12th. A very unsettled period ensued with secondary depressions or troughs of low pressure moving east over the British Isles; rain fell daily in most areas. On the 17th a small but vigorous secondary depression moved rapidly north-east across England giving heavy rain, while the main depression south of Iceland moved east-south-east. In the rear of these disturbances westerly gales were recorded locally in the English Channel. On the 21st and 22nd a small, very vigorous, depression moved east across Iceland and associated troughs crossed the British Isles; widespread gales occurred in Scotland on the 22nd and they were very severe in the extreme north, Beaufort force 11 being reached for a time at Lerwick. Another intense disturbance moved east to the north of Scotland on the 24th and then turned north-east. Severe gales were recorded in the extreme north of Scotland, hurricane force being reached at Wick at 0600 on the 25th. Rain occurred at times in most districts.

In the rear of this disturbance a wedge of high pressure moved east over the British Isles and subsequently high pressure was established over southern Scandinavia. The last six days of the month were cold; among low minimum temperatures may be mentioned 17°F. at Dalwhinnie, 21°F. at Wick and 22°F. at South Farnborough on the 27th. On the 27th and 28th a depression off the west of Ireland moved south-east and was associated with heavy rain in the south-west and local gales on the south-west coasts (2·37 in. of rain at St. Austell on the 27th).

Broadly speaking, rainfall exceeded the average in Scotland except south of the Firth of Forth, around Balmoral and the Solway Firth; more than twice the average occurred in Argyllshire. In England and Wales more than the average occurred in Cornwall, in an area extending from north Wiltshire to Birmingham and locally in south Wales, west Essex and north Cambridgeshire. Less than 50 per cent. was received over much of north-east England, locally on the coast of East Anglia and in part of south-east England.

The general character of the weather is shown by the following provisional values:—

	Air Temperature			Rainfall		Sunshine	
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average	Percentage of possible duration
	°F.	°F.	°F.	%		%	%
England and Wales	75	21	+0·5	75	−4	93	29
Scotland	67	11	0·0	130	0	108	28
Northern Ireland ..	70	28	+1·3	100	−1	104	28

Erratum.—September table, p. 262, Highest temperature in Scotland, *for* 72°F. *read* 70°F.

RAINFALL OF OCTOBER, 1948

Great Britain and Northern Ireland

County	Station	In.	Per cent of Av.	County	Station	In.	Per cent of Av.
London	Camden Square	1·96	75	*Glam.*	Cardiff, Penylan	5·61	118
Kent	Folkestone, Cherry Gdns.	1·20	30	*Pemb.*	St. Ann's Head	4·16	94
,,	Edenbridge, Falconhurst	1·89	53	*Card.*	Aberystwyth	4·78	115
Sussex	Compton, Compton Ho.	2·94	64	*Radnor*	Bir. W. W., Tyrmynydd	4·37	66
,,	Worthing, Beach Ho.Pk.	1·80	50	*Mont.*	Lake Vyrnwy	2·56	43
Hants	Ventnor, Roy. Nat. Hos.	2·20	56	*Mer.*	Blaenau Festiniog	9·51	93
,,	Bournemouth	1·95	46	*Carn.*	Llandudno	2·10	63
,,	Sherborne St. John	2·58	73	*Angl.*	Llanerchymedd	2·65	59
Herts.	Royston, Therfield Rec.	2·26	83	*I. Man.*	Douglas, Boro' Cem.	4·10	90
Bucks.	Slough, Upton	2·26	81	*Wigtown*	Port William, Monreith	5·17	131
Oxford	Oxford, Radcliffe	2·33	81	*Dumf.*	Dumfries, Crichton R.I.	3·44	87
N'hant.	Wellingboro', Swanspool	1·57	62	,,	Eskdalemuir Obsy.	5·97	111
Essex	Shoeburyness	1·04	44	*Roxb.*	Kelso, Floors	2·44	84
Suffolk	Campsea Ashe, High Ho.	1·71	66	*Peebles*	Stobo Castle	2·21	64
,,	Lowestoft Sec. School	1·20	43	*Berwick*	Marchmont House	3·14	82
,,	Bury St. Ed., Westley H.	1·37	51	*E. Loth.*	North Berwick Res.	2·72	92
Norfolk	Sandringham Ho. Gdns.	2·18	72	*Midl'n.*	Edinburgh, Blackf'd. H.	1·61	59
Wilts.	Bishops Cannings	4·41	133	*Lanark*	Hamilton W. W., T'nhill	3·46	106
Dorset	Creech Grange	2·42	48	*Ayr*	Colmonell, Knockdolian	5·86	132
,,	Beaminster, East St.	3·29	74	,,	Glen Afton, Ayr San	..	..
Devon	Teignmouth, Den Gdns.	2·49	64	*Bute*	Rothesay, Ardencraig	10·56	239
,,	Cullompton	3·02	73	*Argyll*	L. Sunart, Glenborrodale	9·22	140
,,	Barnstaple, N. Dev. Ath.	4·28	94	,,	Poltalloch	10·56	214
,,	Okehampton, Uplands	5·35	89	,,	Inverary Castle	17·24	245
Cornwall	Bude School House	5·24	129	,,	Islay, Eallabus	7·93	166
,,	Penzance, Morrab Gdns.	5·99	129	,,	Tiree	6·63	145
,,	St. Austell, Trevarna	7·93	150	*Kinross*	Loch Leven Sluice	3·63	106
,,	Scilly, Tresco Abbey	4·58	120	*Fife*	Leuchars Airfield	2·93	113
Glos.	Cirencester	3·49	105	*Perth*	Loch Dhu	11·93	167
Salop.	Church Stretton	2·17	59	,,	Crieff, Strathearn Hyd.	4·76	121
,,	Cheswardine Hall	1·93	62	,,	Pitlochny, Fincastle	3·91	120
Staffs.	Leek, Wall Grange P.S.	2·39	69	*Angus*	Montrose, Sunnyside	2·83	103
Worcs.	Malvern, Free Library	2·65	89	*Aberd.*	Balmoral Castle Gdns.	1·90	53
Warwick	Birmingham, Edgbaston	2·83	102	,,	Dyce, Craibstone	3·97	118
Leics.	Thornton Reservoir	2·60	93	,,	Fyvie Castle	4·05	106
Lincs.	Boston, Skirbeck	1·74	64	*Moray*	Gordon Castle	3·24	103
,,	Skegness, Marine Gdns.	1·82	66	*Nairn*	Nairn, Achareidh	2·33	102
Notts.	Mansfield, Carr Bank	1·36	45	*Inv's*	Loch Ness, Foyers	4·47	133
Ches.	Bidston Observatory	1·69	52	,,	Glenquoich	14·86	149
Lancs.	Manchester, Whit. Park	2·41	73	,,	Fort William, Teviot	12·59	177
,,	Stonyhurst College	3·52	78	,,	Skye, Duntuilm	7·61	140
,,	Blackpool	3·58	96	*R. & C.*	Ullapool	5·14	109
Yorks.	Wakefield, Clarence Pk.	1·13	39	,,	Applecross Gardens	7·94	133
,,	Hull, Pearson Park	1·34	45	,,	Achnashellach	11·22	148
,,	Felixkirk, Mt. St. John	1·13	39	,,	Stornoway Airfield	4·85	99
,,	York Museum	1·31	49	*Suth.*	Lairg	4·66	125
,,	Scarborough	1·42	45	,,	Loch More, Achfary	9·09	117
,,	Middlesbrough	1·12	37	*Caith.*	Wick Airfield	4·33	146
,,	Baldersdale, Hury Res.	2·46	62	*Shet.*	Lerwick Observatory	5·79	146
Norl'd.	Newcastle, Leazes Pk.	1·58	51	*Ferm.*	Crom Castle	2·52	78
,,	Bellingham, High Green	2·31	59	*Armagh*	Armagh Observatory	2·26	83
,,	Lilburn Tower Gdns.	1·72	46	*Down*	Seaforde	2·65	74
Cumb.	Geltsdale	2·82	76	*Antrim*	Aldergrove Airfield	3·17	106
,,	Keswick, High Hill	4·94	88	,,	Ballymena, Harryville	4·74	128
,,	Ravenglass, The Grove	4·04	94	*Lon.*	Garvagh, Moneydig	3·76	107
Mon.	Abergavenny Larchfield	3·79	90	,,	Londonderry, Creggan	4·56	124
Glam.	Ystalyfera, Wern House	6·14	89	*Tyrone*	Omagh, Edenfel	3·64	99

CLIMATOLOGICAL TABLE FOR THE BRITISH COMMONWEALTH, JUNE 1948

Stations	Pressure: Mean of day M.S.L.	Pressure: Diff. from normal	Temperatures: Absolute Max.	Temperatures: Absolute Min.	Temperatures: Mean values Max.	Mean values Min.	Mean values ½ Max. and Min.	Mean values Diff. from normal	Mean values Wet bulb	Relative humidity	Mean cloud amount	Precipitation: Total	Precipitation: Diff. from normal	Precipitation: Days	Bright Sunshine: Daily mean	Bright Sunshine: Percentage of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	tenths	in.	in.		hr.	%
London, Kew Observatory	1014·0	−2·8	78	46	65·8	52·0	58·9	−0·6	53·9	73	8·6	1·67	−0·48	16	5·4	33
Gibraltar	1017·5	+0·2	89	60	78·9	65·0	71·9	+1·4	66·8	76	3·1	0·14	—	2	11·6	80
Malta	1015·4	+0·2	86	60	79·5	65·2	72·3	−0·4	67·4	65	2·6	0·11	—	3	11·6	79
St. Helena	1019·1	+0·2	71	55	66·3	57·3	61·8	+1·5	57·3	91	8·9	2·22	−0·51	13	—	—
Freetown, Sierra Leone	1013·8	+3·5	88	67	83·7	73·1	78·4	−0·5	75·5	88	8·0	19·39	−0·65	28	4·1	33
Lagos, Nigeria ..	1014·2	+1·8	89	67	83·3	70·9	77·1	−2·4	75·7	87	9·1	9·45	—	20	3·0	24
Kaduna, Nigeria ..																
Chileka, Nyasaland ..	1022·7	+0·4	82	48	75·5	55·6	65·5	+0·5	59·1	63	2·9	0·01	−0·12	1	8·0	71
Lusaka, Rhodesia ..	1020·1	+0·9	79	45	74·9	49·9	62·4	+0·9	54·6	56	1·8	0·00	−0·05	0	9·8	—
Salisbury, Rhodesia..	1023·2	+0·6	74	37	70·6	42·1	56·3	−0·9	50·2	56	1·0	0·00	−0·09	0	10·0	90
Cape Town ..	1021·4	+1·3	74	39	62·9	45·6	54·3	−1·4	46·8	76	5·9	2·86	−1·64	21	—	—
Germiston, South Africa	1024·4	−0·8	71	24	64·6	37·9	51·3	+1·0	39·1	60	0·0	0·00	−0·23	0	9·8	93
Mauritius																
Calcutta, Alipore Obsy.	998·4	−0·9	100	75	94·0	80·8	87·4	+2·3	81·5	84	6·6	12·76	+0·85	14	5·3	39
Bombay	1003·3	−0·7	95	75	90·4	80·6	85·5	+1·5	78·9	81	7·4	8·78	−11·09	11	5·4	41
Madras	1003·1	−0·7	110	77	102·1	83·4	92·7	+2·7	76·1	58	6·5	0·71	−1·26	8	7·4	57
Colombo, Ceylon ..	1009·3	+0·7	88	73	85·8	77·4	81·6	0·0	77·2	85	8·7	11·55	+4·23	25	6·1	49
Singapore	1008·8	−0·1	92	72	89·0	77·3	83·1	+1·6	78·2	79	6·7	6·62	−0·25	12	—	—
Hongkong	1004·2	−1·6	91	72	86·0	77·6	81·8	+0·4	77·9	85	—	17·16	+1·46	19	4·3	32
Sydney, N.S.W. ..	1022·4	+4·5	70	40	61·8	49·3	55·5	+0·8	49·8	79	5·4	7·48	+2·74	13	4·7	48
Melbourne	1023·2	+4·7	63	32	56·7	41·9	49·3	−1·1	44·6	82	6·9	1·33	−0·73	13	3·6	38
Adelaide	1024·0	+5·4	65	40	59·2	46·3	52·7	−0·9	48·1	76	7·7	1·82	−1·26	15	4·0	41
Perth, W. Australia..	1019·4	+1·4	74	39	66·2	49·4	57·8	+1·0	53·1	68	5·0	7·13	+0·19	13	4·6	46
Coolgardie	1022·3	+3·4	73	35	63·3	43·3	53·3	+0·5	46·4	68	3·0	1·34	+0·08	8	—	—
Brisbane	1020·7	+2·4	77	42	68·7	51·3	60·0	−0·2	54·4	68	4·4	8·83	+6·04	10	6·1	58
Hobart, Tasmania ..	1019·7	+5·4	60	31	53·3	39·6	46·5	−0·5	41·4	77	6·6	1·34	−0·89	12	4·1	45
Wellington, N.Z. ..	1018·1	+3·2	61	35	52·0	42·3	47·1	−0·9	44·5	80	7·4	3·05	−1·72	15	3·1	34
Suva, Fiji	1013·4	−0·2	84	66	79·2	71·1	75·1	+0·4	71·3	81	7·9	4·47	−2·24	18	4·0	36
Apia, Samoa ..	1011·0	−0·3	89	69	86·8	73·7	80·3	+1·6	76·7	80	7·1	2·56	−2·42	14	8·2	73
Kingston, Jamaica ..	1013·9	+0·1	93	72	89·8	74·9	82·3	+1·0	75·9	73	4·2	9·69	+5·59	6	9·2	70
Grenada, W. Indies..	—	—	88	73	86·5	76·8	81·7	+2·7	78·0	80	8·1	5·39	−2·86	21	—	—
Toronto	1013·0	−1·7	85	45	75·0	56·3	65·7	+1·9	55·4	69	5·5	4·06	+1·40	9	8·7	57
Winnipeg	1013·2	+1·4	90	35	73·2	50·0	61·6	−0·7	51·6	82	5·7	1·69	−1·42	14	9·3	57
St. John, N.B. ..	1012·3	−1·2	76	42	63·1	47·4	55·3	−1·2	50·8	83	6·6	4·72	+1·45	14	6·4	41
Victoria, B.C. ..	1016·9	+0·1	81	46	68·3	51·5	59·9	+2·9	52·3	92	5·1	1·76	+0·92	7	10·2	64

St. John, N.B.	..	1012·3	−1·2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+2·9	52·3	92	5·1	[illegible]	[illegible]
Victoria, B.C.	..	1016·9	+0·1	81	46	68·3	51·5	59·9						